STUDY OF CUTTING FORCES

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Abstract
In mechanical engineering, the detection of errors that occur during the processing of shaped surfaces of parts remains by far the most important task. Before processing the shaped surfaces, it will be necessary to study the working surfaces of the stamping molds. This article presents methods for determining the geometric parameters of the surface when processing stamping molds on shaped surfaces, in particular, information about the structure of the cutting zone of shaped surfaces, the penetration of the bit into the cutting zone and the control conditions in the cutting zone.

Keywords: strength parameters, diagnostics, models, cutting area, strength, durability, stamping, stamping form, cutting parameters.

Introduction
Special importance is attached to the issues of increasing product quality, increasing processing productivity and ensuring dimensional accuracy in the processing of complex machine-building details. Nowadays, it is an important task to increase the weight of the parameters that should be taken into account in programming in order to increase the productivity of processing details of complex shapes in machines controlled by digital programs. In this regard, in developed countries, including the research centers of countries such as the USA, England, Germany, Japan, and China, the development of optimal parameters of processing modes, the development of the ratio between the processed material

and the cutting tool in accordance with the cutting modes, and the development of complex shapes on machines controlled by digital programs special attention is paid to the improvement of work efficiency in the development of details.

Materials and Methods

In the field of engineering and technology, ensuring the geometric parameters of details and their accuracy indicators is of particular importance in increasing the quality and service life of machinery and automotive products. At the same time, increasing the physical and mechanical properties of the metal surface layer is one of the important tasks. In this regard, in the research centers of developed countries, including the USA, Russia, England, Germany, Japan, and other countries, special attention is paid to the development of technologies that ensure dimensional bending of cutting tools during operation and increase accuracy indicators during mechanical processing of complex surface details.

The experience of processing complex-shaped details on CNC milling machines shows that the current level of technology development is characterized by the concentration of black, semi-clean and clean processing processes in one machine, that is, very many-pass processing. This type of processing is used in automotive industry, machine tool industry, tool industry and other industries. Thus, in the production of parts with a flat surface processed by surface milling, processing in machine tools makes up to 40% of the labor share of the total production.

During the black transition, large deposits of up to 20 mm are removed from the workpiece, which in turn leads to large processing errors. When working with a cutting tool in a clean transition, the required accuracy is controlled by changing the thrust value and the depth of cut and the cutting speed during the cutting process.

In diagnostics, it is determined how to perform control operations in a sequence and how to process the obtained results, while controlling the entire process or a separate operation. Three types of devices are used in technical diagnostics. One of them is the construction of a process model, the development of diagnostic methods based on the use of the built model. In the problem of the first group, each element in the process is studied and includes the following issues: studying the normal functioning of the technological process, dividing the process into possible cases, including the separation of failure combinations; to collect and process statistical data about the technical feasibility of monitoring the signs characterizing the process state, how the probability of dividing process states is divided, and at the same time to study the patterns of failure in individual operations; creating a process model and methods of its construction.

Results

The constant feed of the cutting edge and the contact angle with the machined surface can be obtained from the scheme shown in the useful work coefficient:

$$\alpha = \arccos\left(\frac{b^2 + c^2 - a^2}{2bc}\right) \quad (1)$$

$$e = c \cdot \sin\left(\arccos\left(\frac{b^2 + c^2 - a^2}{2bc}\right)\right) \quad (2)$$

$$\varphi = \arcsin\frac{e}{\alpha} = \arcsin\frac{c \cdot \sin\left(\alpha\cos\left(\frac{b^2 + c^2 - a^2}{2bc}\right)\right)}{\alpha} \quad (3)$$

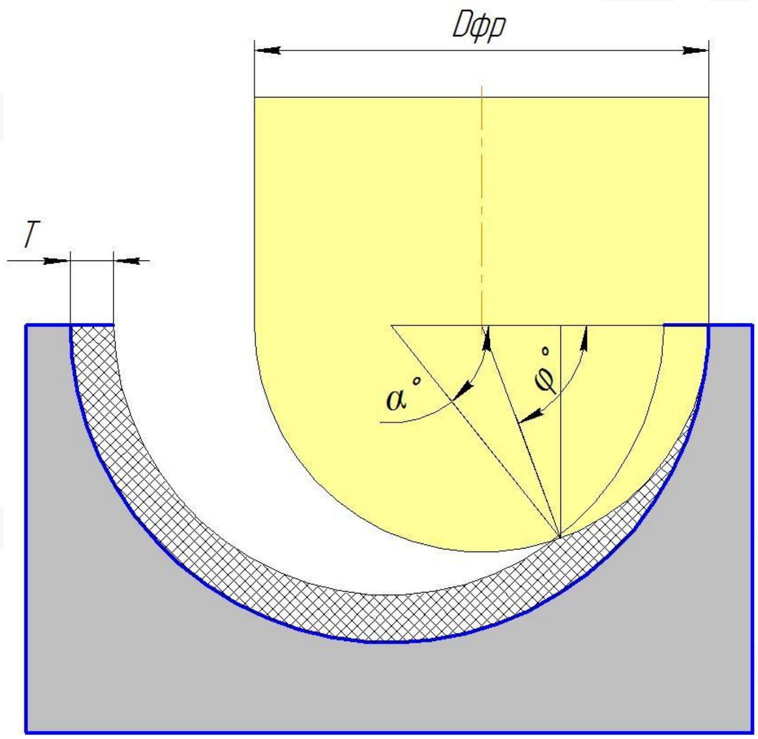

Figure 1. The scheme for determining the contact angle of the cutting edge. $R_{фр}$.; $b=R_{пов}.-R_{фр}=R_{тр}$.; $c=R_{пов}.-T=R_{тр}.+R_{фр}-T$.

$$\varphi = \arcsin\frac{(R_{пов} - T)\cdot\sin\left(\arccos\left(\frac{(R_{пов} - R_{фр})^2 + (R_{пов} - T)^2 - R_{фр}^2}{2R_{тр}(R_{тр} + R_{фр} - T)}\right)\right)}{R_{фр}}$$

$$= \arcsin\frac{(R_{тр} + R_{фр} - T)\cdot\sin\left(\arccos\left(\frac{R_{тр}^2 + (R_{тр} + R_{фр} - T)^2 - R_{фр}^2}{2R_{тр}(R_{тр} + R_{фр} - T)}\right)\right)}{R_{фр}} \quad (4)$$

It follows from the expression that three parameters affect the angle when processing the detail walls.

$R_{тр}$- the radius of the cutting tool path.; $R_{фр}$- the radius of the cutting tool sphere.; T- first pass bet..

Figure 2 shows the graph of an expression that is a hyperbola.:

$$\varphi_i = A\cdot R_{тр^i}^{-0,8} + B \quad (5)$$

from this

$$\varphi_{i+1} = A\cdot R_{тр^{i+1}}^{-0,8} + B;\ \varphi_{i+2} = A\cdot R_{тр^{i+2}}^{-0,8} + B; \quad (6)$$

after

$$A = \frac{\varphi_{i+2} - \varphi_{i+1}}{R_{тр^{i+2}}^{-0,8} - R_{тр^{i+1}}^{-0,8}} \quad (7)$$

here:

$R_{mp.i}$- radius of the trajectory on a randomly selected part..

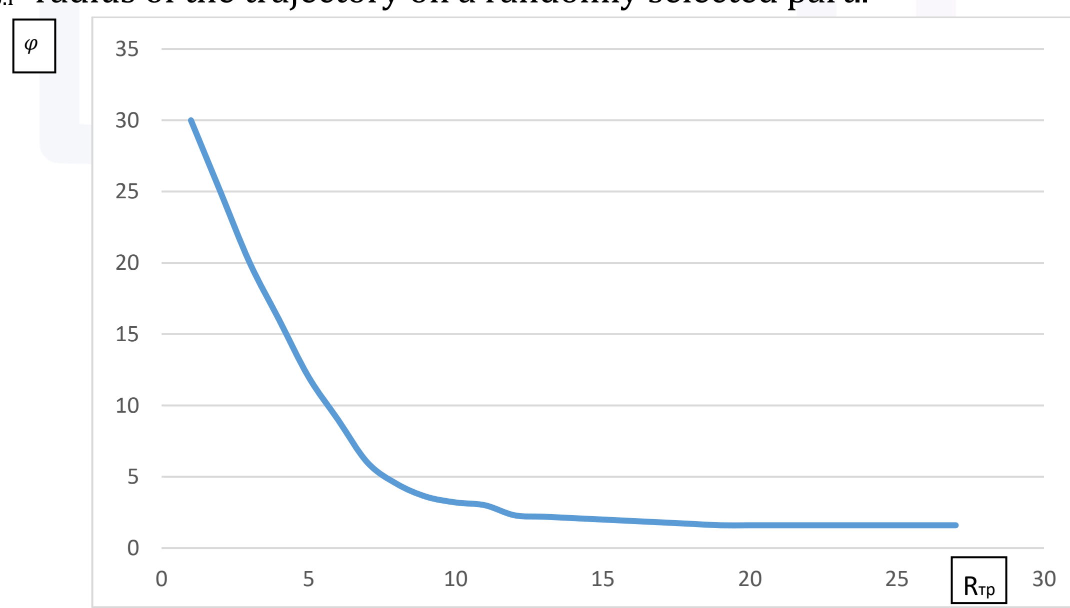

Figure 2. Graph of dependence of φ on Rtr.

$R_{mp.i+1}$, $R_{mp.i+2}$– values are calculated by the following expressions.

$$R_{\text{тр}\ i+1} = 0{,}5R_{\text{фр}} \qquad R_{\text{тр}\ i+2} = 0{,}6R_{\text{фр}} \tag{8}$$

Tthe amount of stock is determined for small processing.:

$$t(\%)=(0{,}01\ldots0{,}2)\cdot(R_{\text{фр}})$$

t(%)for different values of φ_{i+1} and φ_{i+2} parameter values Figure 3 shows. Values for determining the contact angle of the cutting edge of the cutting tool with the surface to be processed.

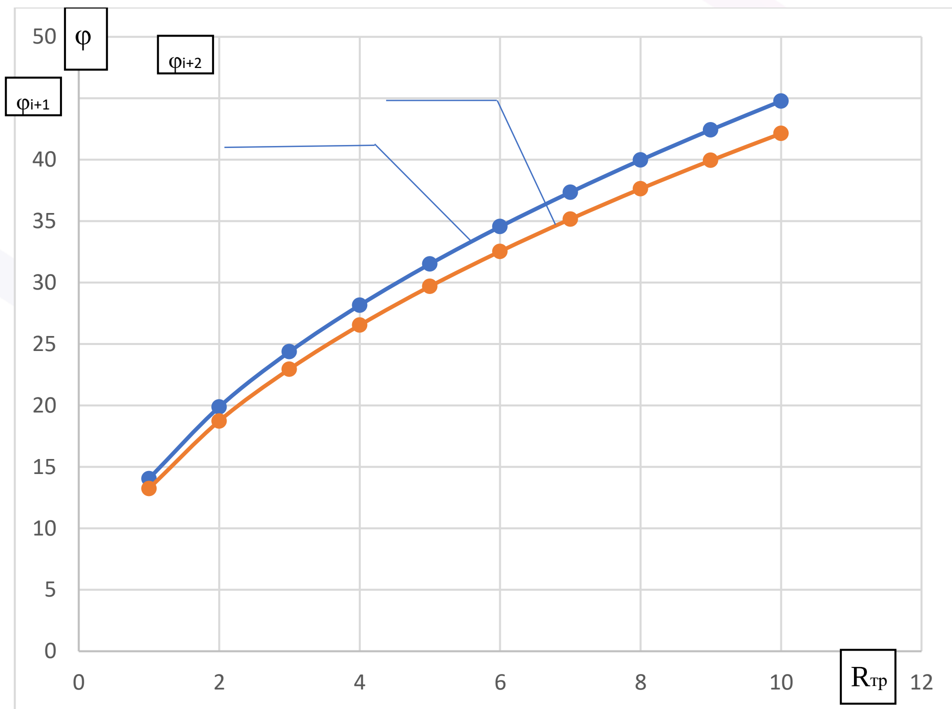

Figure 3. Graph of dependence of φ on Rtr.

Using the expressions and data in Figure 3, a, These empirical coefficients can be calculated, and using the expression, the control system allows you to adjust the cutting force parameters depending on the angle of dependence of the cutting edge during processing, the radius of the processed surface.

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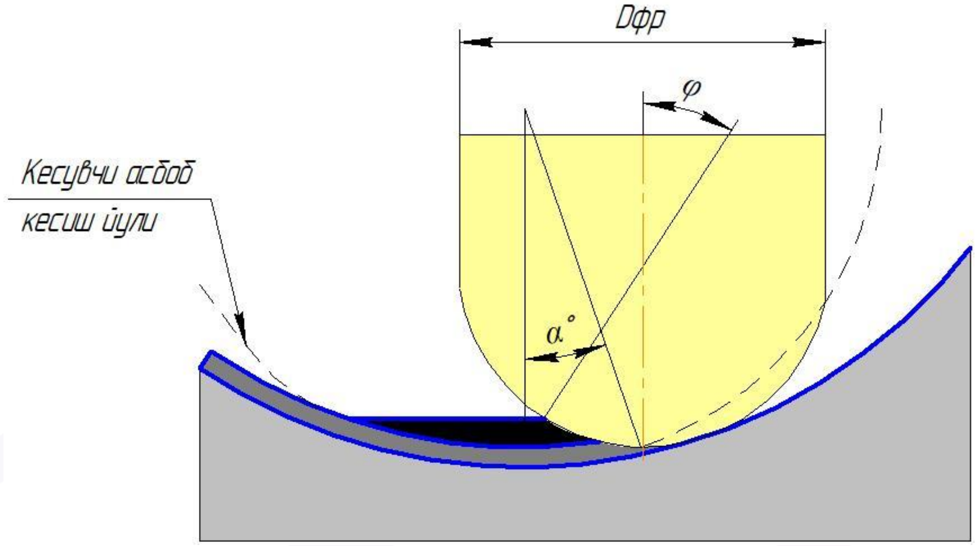

Figure 4. Scheme for determining the contact angle of the cutting edge in the previously untreated part.

$$AB = ACcos\alpha = R_{тр}cos\alpha \Longrightarrow DC = H_{OK} - \left(R_{тр} - R_{тр}cos\alpha\right) \quad (9)$$

Given that:

$$D_{эфф} = 2\sqrt{T_{\Sigma}\left(D_{эфф} - T_{\Sigma}\right)},\ \text{a}\ DC = T_{\Sigma} \quad (10)$$

It follows from the above formula that:

$$ED = \sqrt{\left(H_{OK} - \left(R_{тр} - R_{тр}cos\alpha\right)\right)\left(D_{фр} - H_{OK} - \left(R_{тр} - R_{тр}cos\alpha\right)\right)} \quad (11)$$

First, the contact angle of the cutting edge in the untreated part is calculated by the expression:

$$\varphi = \arcsin\frac{ED}{EO} \Longrightarrow \varphi \quad (12)$$

$$= \arcsin\frac{\sqrt{\left(H_{OK} - \left(R_{тр} - R_{тр}cos\alpha\right)\right)\left(2R_{фр} - H_{OK} - \left(R_{тр} - R_{тр}cos\alpha\right)\right)}}{R_{фр}} \quad (13)$$

Development of control programs in CAM systems is carried out according to 3D models built according to nominal dimensions, that is, the path of the cutting tool is formed along the nominal surface (Fig. 5). But as mentioned above, the forces that appear during cutting tend to move the cutting edge of the cutting tool from the working surface, creating a different surface than the nominal one. Because in practice, to ensure the accuracy of processing, the control program is organized by the geometric parameters tool.

Conclusion

- CNC machines are one of the main means of automating multipass operations in the milling of shaped surfaces, the effectiveness of which depends on the completeness and correctness of using the software control capabilities;
- variation of cutting force in black and finishing processing in a wide range is characterized by multi-pass milling; there are reliable calculation methods and normative recommendations, and in addition, the influence of various performance factors on the number of each transition and cutting methods is not taken into account;
-milling of surfaces has a significant effect on accuracy, and errors in elastic deformations of the technological system are observed in the conditions of black, semi-clean processing;

Recommendations should be made for cutting tool wear under clean and finish machining conditions.

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